THE VALUE OF SMART METERING HOUSEHOLD ELECTRICITY CONSUMPTION

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ABSTRACT

Smart metering presents opportunities for business model creation. However the viability of many potential business models in a smart metering scenario may be dictated by privacy regulation and data sharing arrangements. An understanding by businesses of customers' preferences for the visualisation of their electricity consumption and the degree to which they are willing to share it, is valuable. We present results from two interviews exploring data visualisation and willingness to share personal electricity consumption information. Participants displayed a high willingness to share and a preference for access to additional information when visualising their electricity consumption.

INTRODUCTION

Electricity to the average householder over previous decades has taken the form of an invisible, plentiful and ubiquitous commodity; available at the flick of a switch and "visualised" only upon receipt of an infrequent bill (Faruqui et al. 2010). Furthermore, business models for electricity network operators in Australia do not yet extended far beyond the provision of electricity to customers at regulated tariffs. The introduction of more advanced metering infrastructure such as smart meters and smart networks however, would result in increasingly detailed electricity usage information becoming available not only to the consumer, but to their electricity provider as well (Quinn 2009, Darby 2010).

This scenario of increased visualisation and sharing of electricity consumption information involves a significant overhaul of existing metering infrastructure and may give rise to new markets, new business models and new value propositions for established business models within the electricity market (Quinn 2009). Under a smart metering scenario, knowledge of how customers wish to receive energy-centric information and are willing to share their personal electricity data becomes an important and potentially valuable asset for both existing and nascent business models within the domestic electricity market.

This paper firstly seeks to highlight the potential for business model creation in smart metering scenarios and the nature of potential business opportunities. Findings from two semi-structured interviews with families, concerning visualisations of their electricity consumption are then presented. These findings provide insight into the desirable attributes of electricity use feedback as well as consumer perceptions regarding smart meter privacy. Several areas warranting further research are identified in light of the findings.

SMART METERING

A smart meter represents a replacement for the conventional household electricity meter. Smart meters communicate electricity consumption information to the electricity utility via existing communications infrastructure and in certain instances to the household via in-home displays or website logins (Darby 2010). A smart network is an established electricity network consisting of many individual smart meters communicating with the electricity utility (Darby 2010, Fan et al. 2010).

Figure 1 (below) represents a sketch of the information and cost flows associated with the traditional electricity delivery scenario compared to a smart metering scenario (a bi-directionality occurs to cost flows if solar panels are incorporated).

Establishment of smart networks has already begun in several parts of the US and Europe (Quinn 2009). In Australia, progress toward advanced metering infrastructure varies between states with a progressive smart meter roll-out already underway in Victoria (AER 2011).

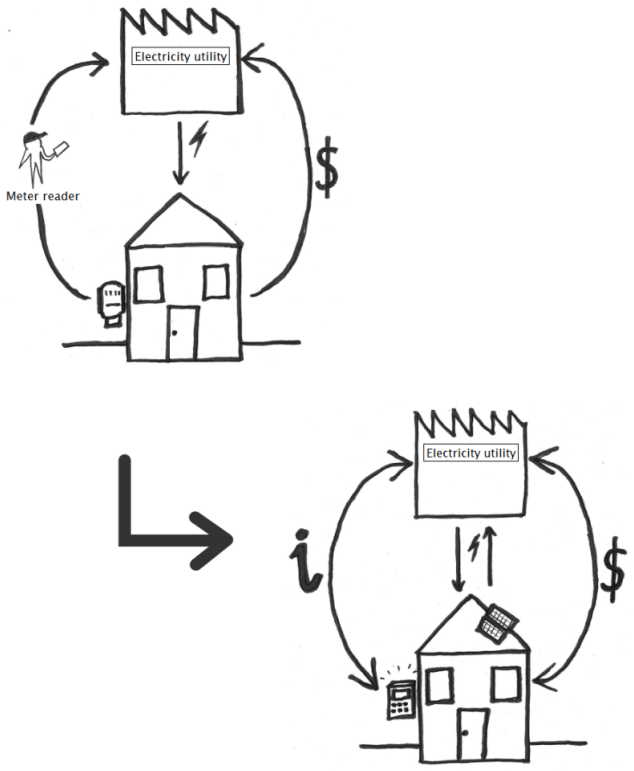

Figure 1: Conventional and smart meter information and cost flows

THE VALUE OF SMART METER INFORMATION TO BUSINESS

Existing smart metering pilots communicate consumption data at time intervals of between 15 and 60 minutes, however this interval is predicted to decrease over time as technologies improve (Fan et al. 2010). Increased data granularity has both positive and negative impacts, with increased opportunities for business innovation but also greater implications for consumer privacy (Quinn 2009). High granularity electricity consumption information allows recipients of the data an unprecedented level of insight into a household's appliance use and behaviour (Fan et al 2010, Efthymiou and Kalogridis 2010). Data-profiling this type of high-definition energy consumption data over time can reveal with some clarity personal information such as:

- The level of efficiency of household appliances operated
- Cooking preferences (for instance the occurrence of microwave cooking over stove/oven cooking)
- Use of air conditioning
- What type and how much TV is watched (Cavoukian et al. 2010)

Information such as this may be highly valuable not only to the household's electricity utility, but potentially to a range of existing and yet-unrealised business models.

POTENTIAL BUSINESS MODELS AND VALUE PROPOSITIONS

Quinn (2009) identifies the likelihood of third parties desiring access to high granularity household consumption data through either the electricity utility or the consumer themselves. With this access, third parties could then tailor value propositions to specific households based on their consumption patterns. Such organisations and their potential value propositions include (but are by no means limited to) those presented in Table 1 (below).

Business model	**Potential value propositions**
Electricity utilities	Improved demand management, load forecasting and fault identification, better integration of renewable energy sources
Marketing companies	Better targeted marketing of various products or services
Energy auditors	Targeted marketing to high-consuming households
Energy feedback designers / retailers	Identification of smart metered residences Targeted marketing of home electricity feedback and management solutions
Regulatory agencies	Better identification of fraudulent activities (for instance drug manufacture) or other unlicensed electricity usages

Table 1: Potential business models and value propositions associated with smart metering (Adapted from Quinn 2009)

As a result of the sensitive nature of this type of information, the prevailing privacy regulation and consent requirements associated with any future smart metering scenario are likely to influence the nature and viability of the business models and value propositions presented in Table 1 (Cavoukian et al. 2010). If smart meter data granularity is to increase as predicted, considerable effort needs to be focussed on finding the appropriate means to ensure

adequate consumer privacy without negatively affecting the potential for business innovation (Cavoukian et al. 2010).

Despite current low levels of data granularity (15-60mins) the potential for smart metering to facilitate business model creation is high (Quinn 2009, ENA 2010). This is particularly so in the electricity management industry, where a move towards smart metering is expected to increase demand for energy feedback and management solutions (Fan et al. 2010, ENA 2010). Great Britain for instance aims to install smart meters into every UK home by 2020, with an in-home display device offered standard with every smart meter (DCCE 2011, Ipsos-MORI 2011).

Therefore, an understanding by business and government alike, regarding how householders conceptualise electricity-centric information, the ways they prefer to visualise their electricity feedback and the degree to which they are willing to share it, is highly valuable. Accordingly, the second part of this paper describes a study involving the visualisation of electricity use feedback, touching on consumer attitudes to privacy and some implications for potential business models.

VISUALISING ELECTRICITY USE FEEDBACK

There is limited literature on near-instantaneous electricity feedback systems (eg. in-home displays) that considers how the feedback is accepted or used by the household. While many studies link the provision of direct electricity feedback with household energy savings (Fischer et al. 2008, Faruqui et al. 2010), few investigate exactly how the behaviour change was actuated, or what is the most effective way of presenting the feedback to users (Wallenborn et al. 2010). Only more recent academic studies explore household interaction with feedback (Hargreaves et al. 2010), the aesthetic and positional issues associated with in-home displays (Riche et al. 2010) and the most effective ways to visualise feedback (Karjalainen 2011). In the case of a significant roll-out of in-home display systems, this information is highly valuable to regulators and industry alike.

Using pre-designed prototypes, Karjalainen (2011) showed participants a range of different electricity feedback visualisations in order to gain insight into the most desirable attributes of the visualisations. Results indicated a general preference for those visualisations which incorporated cost, historical consumption comparison and identification of appliance-specific consumption (Karjalainen 2011). Our pilot study builds on work related both to smart metering and to the visualisation of energy consumption.

METHODOLOGY

As part of the IT Product Designs graduate program: "Ethnography by numbers", conducted at the SPIRE Research Centre (University of Southern Denmark), we accessed smart meter data from two consenting families in Sønderborg, Denmark. These families had voluntarily installed smart meters in their homes as part of a trial with a Danish electricity utility. Hourly consumption totals were relayed to the utility and made available to the families through unique login and password combinations on the utility's website.

Using downloads of the families' raw hourly consumption data, two visualisations were created on the theme of "everyday behaviour"- relating energy consumption to behaviours and activities within the home. These visualisations were presented and discussed with each family during an informal interview conducted at their residence. Two adult representatives of each family were present at both interviews.

The first visualisation involved a computer-generated animation which highlighted the hour of each day at which the highest average consumption occurred. These highest consumption hours accumulated on the left of screen throughout the course of the animation (refer Figure 2 below).

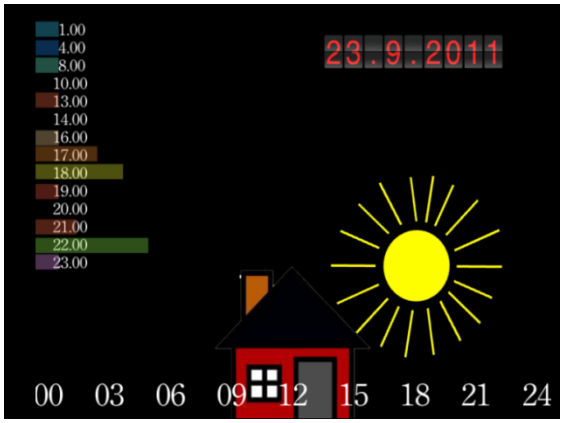

Figure 2: Animation visualisation

In the second visualisation, participants were invited to place picture-cards corresponding to their typical behaviours or appliance usage on a 24 hour timeline. Different days' consumption graphs plotted on A3 transparencies were then overlaid upon the populated timeline, allowing participants to compare the perceived timing of their behaviours with their actual consumption (refer Figure 3).

The intention of both visualisations was to create awareness among the families of the relationship between everyday behaviour and electricity consumption and to provide interest for participants of varying levels of energy awareness.

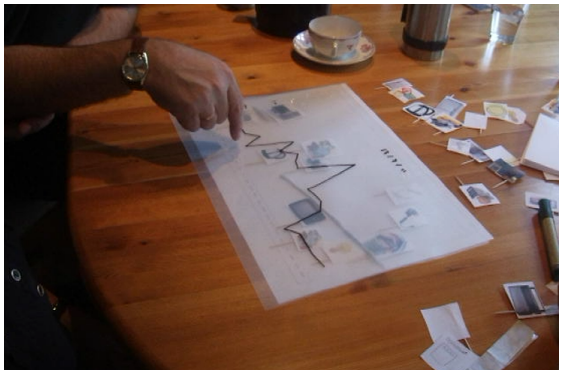

Figure 3: "Everyday behaviour" visualisation

KEY FINDINGS & DISCUSSION: DATA VISUALISATIONS

The two visualisations were well received by both families, who each described the process as beneficial. Each was able to relate to the visualisations; reconciling the timing of their consumption peaks with their own activities with considerable accuracy and satisfaction. Of particular relevance to feedback design, is the level of interest expressed by both families regarding their wish for further information. One participant felt the computer-animated visualisation needed to incorporate more than just the timing of his maximum consumption and thus chose to access raw data from his electricity utility log-in portal for cross-reference:

"Now I know that my standby consumption is what I have to work on, but that's only because I have both results" - (Family 1).

During the presentation of the picture-card visualisation to the second family, both family members expressed a desire to compare this visualisation to further information, such as data from other months. One family member queried whether it was possible to determine the contribution of individual appliances to the data:

"It would be nice to have something to compare the graphs to...You don't know how much the dishwasher or the washing machine would affect the consumption?" – (Family 2)

While the validity of these pilot study findings is clearly compromised by sample size, our findings support Karjalainen's (2011) assertion that feedback systems which allow access to historical comparisons of consumption and which can identify the contribution of individual appliances to total consumption are most popular among consumers. Despite similar results to Karjalainen (2011), this research represents only one small area of a very complex issue. The families in our study had voluntarily installed their smart meters and expressed a high level of energy literacy. Further research is warranted into the influence of levels of energy literacy and interest, upon perceptions of the desirable attributes of energy feedback. In terms of business model creation it is noteworthy that neither family operated any form of in-home display with their smart meter. The level of interest exhibited in our visualisations by the families suggests that such a device (if marketed properly) may be highly desirable at least in our two case studies. Energy management business models also stand to benefit from further research in the vein of Karjalainen (2011), toward maximising the accessibility of in-home displays to the full range of potential end-users.

KEY FINDINGS & DISCUSSION: DATA PRIVACY

While aspects of privacy were not central points of discussion during both interviews, the degree of correlation between one family's behaviour and their electricity consumption prompted a family member to joke:

"It's like having a spy in the house (laughs)"- (Family 2).

However, when questioned about any reservations they had regarding the sharing of their electricity consumption information with their electricity utility (and with us), both families were seemingly unconcerned:

"...we are happy that someone makes us aware [of our consumption]"- (Family 2).

This willingness to share was somewhat of a surprise, considering both families' noticed how their electricity consumption data correlated with their personal behaviours. In terms of their willingness to share their usage information, our exploratory findings are in line with DCCE (2011) who report that privacy ranked behind cost in consumer concerns with smart metering.From a business perspective, the data granularity in this instance is insufficient to establish detailed information on behaviour appliance usage. While this hourly consumption information may be of interest to certain marketing companies, it is expected that higher granularity data would be of greater commercial value.

FUTURE RESEARCH DIRECTIONS

The fact that privacy regulation can influence the viability of business models in a smart metering scenario highlights the importance of an understanding among business and regulators of the human aspects of privacy considerations. While Quinn (2009) and Fan et al. (2010) imply business model creation and robust privacy regulation are largely mutually exclusive, we are not so sure. Heavy-handed privacy regulation could no-doubt compromise the potential for business model

creation, however carefully designed privacy regulation which empowers consumers may deliver greater mutual benefit (DCEE 2011). We therefore envisage our future work to investigate aspects of consumer control of smart meter data and their willingness to share it. For instance, while electricity utilities disseminating smart meter information to third parties is likely to be undesirable, consumers may be willing to provide fragments of their own data directly to third parties in return for desirable value propositions. We therefore aim to investigate the "when", "how much" and "to whom" aspects of consumers' willingness to share electricity information.

Research into the social aspects of smart meter privacy serves to expand our knowledge beyond the current focus on technological aspects (Efthymiou and Kalogridis 2010, Fan et al. 2010). This line of enquiry builds not only on existing studies into smart meter privacy (Quinn 2009, Cavoukian et al. 2010, Efthymious and Kalogridis 2010, Fan et al. 2010), but also build on work by Dourish and Anderson (2006) and Waters and Ackerman (2011) concerning privacy and disclosure in ubiquitous computing and social networking.

CONCLUSIONS

In summary, the potential for business model creation in a smart metering scenario appears to be high, even at relatively modest levels of data granularity. This pilot study serves to highlight the complexity of considerations in designing a smart metering framework which allows for business model creation without compromising consumer privacy. Further research into aspects of privacy including consumers' willingness to share is well justified and future and current business models may benefit from such research. As smart metering is yet to be realised in many parts of Australia, it is an ideal time to conduct research into how best to maximise smart meter benefits to consumers, business and electricity utilities.

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REFERENCES

Australian Electricity Regulator. 2011. AER makes draft determination on Victorian smart meter costs and charges, AER, Victoria. Available at: http://www.aer.gov.au/content/index.phtml/itemid/729796

Cavoukian, A., Polonetsky, J., Wolf, C. 2010. SmartPrivacy for the Smart Grid: embedding privacy into the design of electricity conservation, Identity in the Information Society, Springer.

Darby, 2010. Smart metering: what potential for householder engagement? Building Research & Information 38 (5):442-457.

DECCE. 2011. Smart metering implementation program: Response to prospectus consultation; Supporting document 1 of 5 Data access and privacy. Department of Energy and Climate Change and the Office of Gas and Electricity Markets. London.

Dourish, P., and K. Anderson. 2006. Collective information practice: Exploring privacy and security as social and cultural phenomena. Human-Computer Interaction 21 (3):319-342

Efthymiou, C., and G. Kalogridis. 2010. Smart Grid Privacy via Anonymization of Smart Metering Data. Paper read at Smart Grid Communications (SmartGridComm), 2010 First IEEE International Conference on, 4-6 Oct. 2010.

ENA. 2010. National strategy for smart electricity networks Energy Networks Association 20 September 2010. Available from: http://www.ena.asn.au/udocs/-2010/09/National-strategy-for-smart-electricity-networks-September-2010.pdf.

Fan, Z., Kalogridis, G., Efthymiou, C., Sooriyabandara, M., Serizawa, M., & McGeehan, J. 2010. The new frontier of communications research: smart grid and smart metering. Security, 115-118.

Faruqui, A., S. Sergici, and A. Sharif. 2010. The impact of informational feedback on energy consumption-A survey of the experimental evidence. Energy 35 (4):1598-1608.

Fischer, C. 2008. Feedback on household electricity consumption: a tool for saving energy? Energy Efficiency, 1, 79–104.

Hargreaves, T., Nye, M., & Burgess, J. 2010. Making energy visible: A qualitative field study of how householders interact with feedback from smart energy monitors. Energy Policy, 38, pp6111-6119

Ipsos-MORI. 2011. Exploring awareness, support and preferences for the smart meter roll-out. London.

Quinn, E.L. 2009. Smart Metering & Privacy: Existing Law and Competing Policies, SSRN eLibrary

Riche, Y., Dodge, J., Metoyer, A.R. 2010. Studying always-on electricity feedback in the home. Paper read at CHI (ACM Conf. on Human Factors in Computing Systems), 10-15 April 2010, at Atlanta, Georgia, USA.

Wallenborn, G., Orsini, M., and Vanhaverbeke, J. 2011. Household appropriation of electricity monitors. Internat. Journal of Consumer Studies 35 (2):146-152.

Waters, Susan, and James Ackerman. 2011. Exploring Privacy Management on Facebook: Motivations and Perceived Consequences of Voluntary Disclosure. Journal of Computer-Mediated Comm. 17 (1):101-115.